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PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED:

"SWITCH ELEMENT"

This invention is described in the following statement:

This invention relates to a switching element and more particularly to a switching element which can be mounted onto a printed circuit board.

In one form the invention is said to reside in a switch element for mounting onto a printed circuit board, the switch element having a bearer element and a contact element, both the bearer element and the contact element being formed from an electrically conductive material and the contact element being formed from a resilient material.

In one embodiment the bearer element and the contact element may be of an integral construction.

Alternatively and preferably the bearer element and the contact element are separate components assembled together.

Preferably the contact element is a shallow dome shape.

The contact element may be provided with dimples in a concentric ring close to the centre of the dome which would reduce dome travel to prevent over extension of the dome and improve contact between the dome and tracks or pads on the printed circuit board.

Preferably the bearer element is a peripheral retainer for the contact element.

Preferably the bearer element has an inwardly facing C-shaped cross sectional shape to provide a recess to act as the peripheral retainer for the contact element by receiving at least a portion of the rim of the contact element in the C-shaped member recess.

Preferably the bearer element has a substantially planar base to enable it to be affixed to a conductive track on a printed circuit board by solder, a conductive

adhesive or a like process. A solder paste may be provided on the planar base to assist with soldering the switch element to a printed circuit board. Alternatively the solder paste may be provided onto a printed circuit board onto which the switch element may be affixed.

The inner periphery of the planar base may be provided with a slight downwards angle to contact a printed circuit board in use and form a barrier against the ingress of soldering fluxes or other residues of the fixing process onto the central region where a contact pad is located.

Alternatively the base of the bearer element has a plurality of pins to enable it to be mounted to a printed circuit board.

The bearer element may include bridges around its periphery to enable the bearer element to bridge tracks on the printed circuit board which it is not intended that the bearer element contact and this would also allow draining of the switch element if printed circuit board washing processes were used during manufacture.

The bearer element may be shaped in any desirable shape such as circular, square, rectangular or triangular and the contact element received in the bearer element may be a corresponding shape either with a continuous periphery or with legs as extension of the dome shape extending into the recess of the bearer element.

One method by which the switch element may be manufactured is by forming the two components and then distorting the contact element so that its rim can be placed into the bearer element. Alternatively the bearer element can be partially fabricated into a right angled edge component, the contact element placed into it and the top edge of the bearer element rolled in to form the C-shaped recess with the contact element captured within it.

The bearer element maybe manufactured from a material such as tin plated

high tensile steel or other suitable material. The contact element may be manufactured from steel, stainless steel or the like.

Hence it can be seen that the proposed device, which can be described as a switching element, is a unit formed of conductive materials such as metal. The unit is nominally fabricated from two parts which, once assembled, are ordinarily inseparable. As discussed later the switching element may also be constructed as a single component.

The proposed device is intended for mounting upon a substrate such as a Printed Circuit Board (P.C.B.), or a similar rigid or flexible substrate which features appropriate conductive pads and traces upon its surface. When combined with the conductive pads and connecting traces of the substrate, the proposed device is able to operate as an electrical switch which may be connected to an associated electrical circuit. Such an associated circuit will generally be some type of system incorporating electronic logic functions.

The proposed switching element offers a number of significant and very desirable features which are realisable when it is incorporated upon a substrate to form a "key-pad" or "key-panel" of "button-switches", which may then be used as a component of a broad range of electronic equipment, appliances or instrumentation. Such an associated circuit might be a device which incorporates discreet electronic logic components or a micro-controller to interpret, and act in accordance with, the signals conveyed from a key-pad.

Such applications are presently served by devices commonly known as "dome-switches", or simply as "domes". These devices are made as a domed element, with a round or other, derived shape, derived plan-form, from conductive sheet material, generally a very thin, resilient metal. High volumes of domes are widely used in electronics industries.

In contemporary laminated key-panels, the shape of the domed element used serves two purposes:

Firstly, the central portion of the domed element, in its relaxed or un-actuated state, is raised above the plane of the element's rim, ensuring that the central portion is poised above, yet electrically isolated from, a contact surface below the dome. The clearance between these two elements is generally about one or two millimetres (mm.). The rim of the dome, when not actuated, is the only part of the unit which is in contact with an associated substrate, such as a P.C.B. Upon such a P.C.B. is conductive pad, generally in the form of a full or partial annular ring, upon which the dome's rim sits, being electrically in contact with it. This rim-contact pad is electrically isolated from a centralised contact pad which forms the second node of a simple switch, with the contacting element being the dome itself.

Secondly, the shape of the dome and the springy nature of the sheet material from which it is formed means that, when the dome's central portion is depressed (by a finger), it can be caused to deform in a sudden or "snap" action. The element, partly 'flattened" in this way, can be made to electrically connect the inner and outer contact-pads upon a substrate such as a P.C.B. As this actuating pressure is steadily released, the domed element, due to the effects of its mechanical hysteresis will delay its return to its normal, un-actuated state, until it suddenly releases with a "snap-action". This snap-action serves the very important function of providing tactile feedback to a human operator of the key-panel switch, ie; it signals to the operator the impression that a switching action has indeed occurred. This hysteresis also serves as a contact de-bounce mechanism, although this is not crucial these days because micro-controller circuits, as commonly seen in situations using dome-switch key-pad fabrications, can easily ignore the effects of contact-bounce.

The proposed device generally addresses a large proportion of those applications which are presently served by laminated dome-switch fabrications, with such applications including "key-switches", "key-pads", "key-panels" or "buttons". However, the proposed device also redresses a number of issues which

are problematic to the use of simple "naked domes". These issues will be identified in the following detailed proposal.

The proposed device, which can be described as a switching element, is a unit formed of conductive materials such as metal. The unit is nominally fabricated from two parts which, once assembled, are ordinarily inseparable. When the proposed device is associated with a pair of conductive pads, normally electrically isolated from each other, on a substrate, a momentary-action switch is produced.

The switch element according to the present invention has a number of advantages over existing free dome switch components. These include:

- The edges of the contact element do not bear directly onto the foil of the printed circuit board and hence there cannot be wear.
- The switch element can be mounted vertically of horizontally as there is no danger of migration of the switch element as there can be with domes.
- Installation without the necessity of using a spacer may give a cheaper assembly.

In the following description:

The retaining and mounting part is referred to as the "bearer-element".
The switching part, a diaphragm, is referred to as the "contact-element".

Some terms used in this specification.

The terms "dome", "dome-switch" and other references to domes are used generically.

The term "P.C.B." refers to a Printed Circuit Board, a rigid or flexible substrate with conductive patterns upon it. These conductive patterns and connections may be on one or both sides of the substrate, and may be connected, in the case of double-sided P.C.B.s, from one side to the other by plated-through holes, commonly known as "vias". Vias are often a feature of key-panel substrates used by existing devices and may also feature in fabrications employing the

proposed device. The following proposal does not dwell on the features of Printed Circuit Board (P.C.B.) substrates, except where such features are considered in conjunction with features of the proposed device.

The term "S.M.D." refers to Surface Mounted Devices. The proposed device may be a S.M.D. although a variant with pins for through-hole mounting is possible. In contemporary electronics manufacturing practices, many or most components are S.M.D.s which can be mounted on a P.C.B. by robotic pick-and-place machines, for subsequent soldering by automated re-flow ovens. These S.M.D. processes are standardized and can also be used to mount the proposed device.

The proposed device calls for two key elements - firstly, a tailored containment structure (the bearer-element), formed in metal and, secondly a conductive diaphragm (the contact-element), formed of thin, tensile metal, such as stainless steel. The bearer-element features differing preparations of its upper and lower surfaces, due to their different functions. The upper, inner surface of the bearer-element has a hard, burnished facing, such as nickel-plating, for service as a bearing surface, either as a thrust-bearing or as a knife-edge bearing, for a captive contact-element. The bearer-element also has a cantilevered, inward-facing lip which serves to retain a captive diaphragm or dome. The crease formed by the cantilevered lip of the bearer-element may serve to engage the rim of a captive contact-element in a light interference-fit, to form a knife-edge bearing. This device is, most importantly, a Surface-Mounted Device (S.M.D.), although a "through-hole", pinned version is possible. The lower or outer surface of the bearer-element may be plated with tin or an alloy of tin, or some other metal or alloy, to facilitate bonding by some form of fusion, to a substrate. Additionally, the lower, bonding surface of the bearer-element may be coated with a soldering alloy or compound, including possibly, a soldering flux or resin. The lower surface may be simply "tinned", in the same manner that any other electronics component designed to be fixed by solder-paste and re-flow soldering, has its soldering surfaces pre-tinned. The exposed outer portion of the retaining lip may feature a surface with a matte-

finish, in lieu of a reflective surface, to facilitate heat absorption in re-flow ovens which employ radiant, infra-red heating processes, but the contact element itself may be polished and reflective. The contact-element may be typically made of nickel-plated, stainless steel, or any suitable metal. Practical examples of the proposed device would likely utilize different metals and surface-treatments for the two elements comprising the device.

The switch element according to the present invention may be mounted to the printed circuit board by soldering. The solder can be heated by using RF heating / induction-heating / eddy-current-heating or by laser heating.

The contact element is a diaphragm which may be, but not essentially so, of a domed form. The diaphragm may be of a flattened form, because the presence of the bearer-element provides a small clearance in supporting the contact element above an associated substrate. The contact element is made captive within the bearer element, by various described means, at manufacture, resulting in a device which can be treated thereafter as a single unit. In all normal circumstances of use, the bearer-element and the contact-element are essentially inseparable.

The views of Figures 1 to 4 illustrate only the basic, external form of the proposed device, with crucial functional details not shown. Significant features which provide the full function of the proposed device are described in following pages.

Figure 1 shows an exploded perspective view of a contact-element 1 before fitment to an associated bearer-element 2. In this example, the contact-element 1 is a diaphragm in the form of a shallow metal dome. The diameter of the contact-element is such that its rim 3 will, in one of several options, be held captive by the lip and inner surfaces of the bearer element which is cantilevered toward the centre of the bearer-element. The rim of the diaphragm may rest upon the hard, burnished inner surface of the bearer-element, or may be lightly constrained by the internal

"crease" formed by the retaining lip. The dimensions and profile of the diaphragm can be such that, in its un-actuated state, it will be lightly pinned by the retaining lip, to the bearing surface, below, by the "upper, inner" lip of the bearer-element. This is one method among several, of preventing the contact element from "rattling" inside the bearer-element. Fine adjustments in design detail or dimensions of the bearer-element and associated contact-element may be used to exemplify selected traits of the proposed device.

Figure 2 shows the contact-element retained within the bearer element. The proposed device consists of two elements, which, once assembled together, form a unit which is expected to be inseparable in all ordinary circumstances of application.

Figure 3 shows the under-surface 4 of the bearer-element. This fixing surface is plated or tinned or otherwise coated with a metal or alloy, to facilitate bonding to a substrate, for example, a Printed Circuit Board (P.C.B.), by any of a number of forms of soldering or fusion-welding process. Generally the area shown by the shading 4a can be the region that mates with a pad on a printed circuit board by soldering, conductive adhesive or the like. Essentially, the proposed device is a Surface Mounted Device (S.M.D.), which can be treated, in all respects, as any other S.M.D. - that is, it can be placed on a P.C.B. by existing automated pick-and-place assembly equipment for subsequent soldering by existing re-flow oven equipment. The proposed device is ideally suited to these automated fabrication processes, but may alternatively be bonded to an appropriate substrate by any of several processes of fusion-welding.

Figure 4 shows a plan view of the proposed device, magnified approximately 10 times. The contact element 5 is enclosed about its rim by the bearer element 6.

Figure 5 shows a plan and cross sectional view of the proposed device,

reduced to an approximate actual size 7. Item 8 shows a side elevation view of the device, approximately actual size, mounted upon a substrate such as a P.C.B. Item 9 shows a small hole which is ordinarily provided as an air-vent to reduce the effects of pneumatic damping when the contact element is actuated. The hole also serves as a via to bring an electrical connection from a central contact pad associated with a switch made using the proposed device in conjunction with a P.C.B. or other substrate.

Materials used to fabricate the proposed device must necessarily be electrically conductive and will generally be metallic, although not essentially so. The bearer-element will generally, but not essentially so, be made of sheet metal which has different characteristics than the sheet material used to produce the contact-element. The bearer-element needs to be relatively strong with rigid properties, perhaps typically about 100 micro-metres thick. The contact-element, a diaphragm or dome, should be highly resilient, of a springy material, perhaps typically about 50 micro-metres thick. Typically, the device may be about 12 mms. in diameter with a height of perhaps 1 to 2 mms. above the plane surface upon which it is mounted. The proposed device may be smaller or somewhat larger in any or all of its dimensions, and some of its features may be varied to provide specific advantages as detailed in following pages.

Figure 6 shows three loose devices and associated placement positions upon a P.C.B. Item 10 is a P.C.B. with, for illustration purposes, a copper foil pattern over most of its upper surface, except for insulating regions formed as etched annular rings 11. These non-conducting rings serve to electrically isolate the outer rim-seating area 12 of each switch location, from the inner, concentric contact pads shown as item 13. Item 14 shows a connecting via and air-vent. Item 15 shows the proposed device, permanently bonded to the P.C.B. substrate.

Figure 7 shows a magnified, side-elevation view of the proposed device fixed to a substrate 16. For the purposes of illustration, the device is shown in this

elevated, single-plane sliced view, and a P.C.B. will generally be illustrated to serve as a typical substrate. Item 17 is the sliced side-view of the proposed device, shown in its un-actuated state with the lower surface of its bearer-element bonded 18 to the outer concentric connection pad on the P.C.B. This very secure means of mounting is a key feature of the proposed device. Mounting upon a P.C.B. can be achieved by standard, automated pick-and-place production equipment for S.M.Ds. for subsequent soldering by standard automated reflow-oven soldering systems. The bonding surface of the proposed device can be "tinned" in the manner that any other S.M.D. component is pre-tinned. The device would be placed upon a P.C.B. which has had, in a prior action, an appropriate pattern of solder-paste applied by a paste-mask, in a standard process, to the surface pad upon which the device is to be fixed. The device is ideally suited for fixing by lead-free soldering processes and materials, as lead-based soldering alloys are phased out of electronics industries, world-wide. Further, the proposed device can be efficiently affixed to a substrate by a process of fusion-welding which may, or may not, also involve the use of solder-like coatings. Such fusion-bonding processes will be achieved through the use of a proposed companion tool-head, using precisely controlled electric current to rapidly bond devices to a substrate, either serially, or as a complete array in one action. The bonding surface of the device may be pre-coated with a solder compound which might include a small amount of flux, to assist in the effective fusion of alloy coatings, respectively, the bonding surface of the proposed device, and the corresponding solder-pad on an associated P.C.B. Other heating processes, such as lasers might also be used. The device can also be manually soldered for prototyping purposes.

Figure 8 shows the device 17 depressed, normally by finger-pressure 19, at its centre. The pressure represented by 19 causes the conductive contact-element to connect the central contact-pad on the P.C.B., to the outer contact ring on P.C.B., which is permanently connected to the perimeter of the proposed device. It is this momentary connecting action, maintained as long as mechanical pressure is applied, that serves to provide the functions of a switching device. The

characteristics of the contact-element provide a mono-stable switching action - when pressure upon the contact-element is released, contact should be quickly and cleanly broken. If the contact-element is domed in shape, this make and break action will have a very desirable hysteresis or "snap-action". The proposed device notably permits a broad range of switching actions, from a "soft-touch", non-snap action, to a very noticeable snap-action which can be quite exaggerated, due to the very strong dome-retaining properties of the proposed device. The central contact pad 20 is shown connected through a via 21 which also serves as a vent, to a circuit track 22 on the lower side of the P.C.B. Other means of connecting the central contact pad are provided for by the proposed device, namely, for use with single-sided P.C.B. substrates.

A significant feature of the proposed device is its very firm constraint of the rim of the contact-element, by the bearer-element. In the likely case of the contact-element being of a domed form, in no circumstances can the rim of the dome "flip" upwards when the dome is depressed as shown in figure 8. Domes with a simple circular plan-form, as illustrated in these diagrams, would normally have an un-desirable, inherent tendency to try to "flip" "inside-out" in some circumstances of operation. The proposed device virtually eliminates this innate tendency, firstly by the fact that the rim is "tied down", and secondly, because of the action of the proposed device's "restrictor-ring" which is shown in following diagrams. In fact, the simplistic, round plan-form of domes, being problematic, have given way to derived, non-circular, plans-forms in conventional dome-switch applications. A key feature of the proposed device is that it constrains even simplistic circular domed elements to behave in only one, desirable, mode. The proposed device may, however, exploit virtually any plan-form shape of dome as its contact-element, and in fact, any sensible overall shape may also be assumed by the proposed device.

Figure 9 shows the proposed device in a cross-sectioned, sliced elevated view. The associated inset diagram, further magnified, shows the bearer-element in greater detail. Item 23 is a portion of a substrate P.C.B. The bearer-element 24 is

shown bonded 25 to the perimeter contact pad 26. Item 28 is a slight step near the perimeter of the contact-element, dimensioned so that, in the case where a very discreet profile is required, there is no discernible ridge on the surface of the proposed device. Item 29, a restrictor ring is a turned up edge to the inner edge of the bearer element, provides a significant constraining feature of the bearer-element, which ensures that the contact-element, when actuated, can only deform in its desirable mode. In this mode, when the central region of the contact-element is brought to bear upon the central contact pad upon a substrate, the restrictor-ring, 29 prevents the perimeter region of the contact-element, typically a dome, from being flattened. This in turn ensures that the contact-element remains at all stages, within its mono-stable behaviour mode, thus preventing the contact-element from remaining in an actuated state after all actuating pressure is removed.

Figure 10 shows the proposed device, in an actuated state, due to a deforming pressure being applied to its central region, making contact. Item 30 illustrates how the "restrictor ring" 31 forces the domed contact-element to maintain, at all times, a proper mode of deformation, ensuring it stays well within monostable conditions.

Figure 11 shows a detent 32 which is another means of providing a restrictor-ring, which achieves the same outcome as described by items 29 associated with Figure 9. This detent can be formed as a continuous concentric indentation in the lower surface of the bearer-element, or it may be a series of dimples following the same general path as a continuous indentation.

The bearer-element ensures that contact-element cannot move laterally, or "migrate" out of position, as can occur in conventional containment systems. It also serves to prevent the rim of the contact-element from "flipping" upwards when deforming forces are applied to actuate a switch. The bearer-element, in holding captive its contact element, means that the proposed device, as shown in Figures 7 and 8, does not need any form of overlay in order to function as a switch, as is

required by conventional dome switch systems. However, in many practical situations, an overlay or facia, featuring key-legends or presentation artworks, or a facade of moulded keys, may be applied. Features that enhance this requirement are shown in later pages.

Virtually all key life-span issues associated with domes are improved by the proposed device. Further, because the rim of a contact-element never comes into direct contact with metallic foil patterns on a P.C.B., there is no chance of wear and eventual failure of the substrate.

As shown by figure 10, a domed contact-element is raised slightly above the surface of its associated substrate, due to the thickness of the material used in the bearer-element. This elevation is very slight, a mounting to perhaps less than 100 micrometres. Ostensibly, this causes an over-centring effect when a dome, incorporated in the proposed device, is fully actuated. In practice, this hyper-actuation is insignificant, and, in any event, is more than compensated for by the constraining effects upon the rim of a domed element, by the bearer-element of the proposed device.

Also illustrated by Figure 10 is the fact that the proposed device separates the rim of the contact-element from the surface of the substrate. In the case of a P.C.B., this surface can be un-even and the copper-foil contact pads are generally quite thin and unsuitable as a bearing surface for a hard-edged dome. The proposed device provides a very consistent contact-element bearing feature as detailed in Figures 12 to 15. This, coupled with the other features of the device should lead to a relatively longer, more reliable operational life for the proposed device.

Figures 12 to 15 illustrate the means by which the bearer-element retains, supports and constrains its associated contact-element, which must necessarily have a form and dimensions which exactly suit the form and dimensions of the

bearer-element, according to the features desired for the proposed device. Thus, slight variations in the dimensions and the profile form of the bearer-element and its companion contact-element can be adjusted in small increments to exemplify several modes of operation in the device. Figures 12 to 15 show the two basic forms of contact-element support. Figures 12 and 13 illustrate a "knife-edge" bearing between the contact-element and the bearer-element. Figures 14 and 15 show the bearer-element supporting the contact-element by means of thrust-bearing surfaces.

Figure 12 shows the relevant section, in profile, of the proposed device in its un-actuated state. Item 33 is the substrate with the bearer-element shown securely bonded to it 34. Item 36, the contact-element, is shown in its un-actuated state, with the edge of its rim lightly constrained by the internal perimeter crease of the bearer-element. This serves as a knife-edge bearing for the contact-element, which in these cases is a dome.

Figure 13 shows the device depicted in figure 12 in its actuated state, caused by a deforming force, (finger-pressure), upon the centre area of the proposed device. In this case, the deformation of the dome, 38, has an inherent, slight effect of splaying the rim of the dome outwards. This slight outward movement of the dome is constrained by the bearer-element as shown by item 37. The lower surface of the dome moves towards the plane of the substrate, until its movement is halted by the "restrictor-ring" (or "detent") 39. This detent effectively prevents any tendency for the dome to fail to return to its normal, un-actuated state when the actuating force is released, by maintaining the dome in a non-equalised state of tension. The dome always wants to, and can only return to, its correct un-actuated form. This "knife-edge" bearing system also means the dome is never loose, and therefore cannot rattle.

Figure 14 shows a means of dome support in the form of a thrust bearing. The internal surface 40 of the bearer-element is of a hard, burnished material, such as nickel-plated steel, upon which the rim 41 of the dome sits. The diameter of the

dome is slightly less than the maximum internal diameter of the bearer-element, such that, when the dome is fully depressed, such actuation causes the dome to splay outwards until its rim is lightly in contact with the internal crease of the bearer-element. This small gap, or "rim-clearance", is shown between items 40 and 41. The retaining lip, 42 is arranged so that the dome, in its un-actuated state, is very slightly constrained by the lip, preventing the dome from "rattling". Whilst the rim-clearance allowance for the thrust-bearing permits a slight lateral movement (perhaps less than one mm.), this is of no practical consequence. In fact, conventional dome-switch fabrication methods generally have an innate requirement for such rim-clearances.

Figure 15 shows the device depicted in Figure 14 in its actuated state. In this case, the dome is fully depressed, and its rim has splayed outward, slightly, to incipiently engage 44 the internal crease of the bearer-element. The "restrictor-ring" has, as before, acted to prevent any tendency towards an in-correct deformation mode in the dome.

Whilst the Figures 12 and 13, 14 and 15 illustrate two bearing styles in the proposed device, very small adjustments of relative dimensions can provide a bearing action which falls somewhere between a full "knife-edge" and a "full "thrust-bearing". For example, the device might be configured as a thrust-bearing for 50% of the travel caused by dome actuation, upon which the dome-rim engages the internal crease of the bearer-element, so that continued progress of dome actuation is constrained by a knife-edge bearing effect.

The constraining effect of the bearer-element upon the perimeter of the dome can deliver a slight "sharpening" of the hysteresis, or "snap-action" of the dome, a generally desirable outcome. The same constraining effect might serve to reduce any eventual "fraying" effect upon the rim of the dome.

A further, useful outcome of the bearer-element's very effective containment

of the contact-element, is that, in the case of a domed contact-element, a somewhat stronger snap-action may be exploited, because the proposed device is much more robust than contemporaneous containment systems, virtually eliminating the opportunities for domes to escape from capture in ordinary circumstances of use. In contemporary key-panel fabrications, such "migration" of domes, under, over or between various, laminated spacer and retaining overlay systems is always possible, if mitigated somewhat by strong adhesives, materials and assembly procedures.

Figure 16 shows that the proposed device can be produced so that its profile, in its un-activated state, 45 is virtually indistinguishable from an ordinary "naked dome" retained by conventional laminated spacer systems. This is achieved by tapering the bearer-element to an acute angle at its rim 46, shown with an optional overlay added.

Figure 17 shows the proposed device, configured with an exaggerated containment rim, 47, again with an optional overlay. This prominent rim provides a tactile positional cue to human operators of key-panels, often a very desirable feature. Significantly, the prominent rim of the proposed device, in this case, provides a very firm support for an overlaid facia. In conventional dome-switch systems, such tactile features can be provided by similar embossed features as shown by item 48, but such raised features must rely on the rigidity of plastics materials used in the facia. This need for rigid sheet materials conflicts with a need for such materials to also be very compliant to the movements of a domed element. In some cases, such rigidity in an embossed overlay can give rise to an annoying "double-click" when a dome is depressed through its overlaid, embossed facia-dome. Further, such rigid, un-supported tactile prominences are prone to eventual fracture due to brittleness associated with rigidity. The proposed device offers very effective support for tactile key-panel features, allowing softer, more compliant overlay materials, for a longer key-panel life-span, free of fractures and "double-clicking" effects.

Figure 18 shows another form of the proposed device, where a contact-element without a domed structure is incorporated. This serves to provide a quiet, "soft-touch" switching action, if such an action is desirable. A small amount, typically about 100 micrometres, of contact clearance is provided by the thickness of the material in the base of the bearer-element, so this clearance may be increased as detailed by item 49. By inference, the proposed device may be configured for a wide range of switching actions, ranging from "soft, non-snap" to "hard, snap-action", with the added stresses of harder actions having a reduced effect upon the proposed device, due to its ruggedness.

Figure 19 illustrates the concept of a further exaggerated perimeter 50 in the proposed device, providing a depression into which an actuating "button", 51, can be located, to produce a tactile key-panel with a tailored snap-action. Item 52 is a panel with holes which serve to retain the keys. Coupled with the fact that the proposed device is conceived for high-speed, fully automated fixing to P.C.B.s or other substrates, the device style, 50, could, for example, be used in high-volume manufacture of computer keyboards.

Figure 20 shows the proposed device configured for use with single-sided P.C.B. substrates, as sometimes required for high-volume, low-cost manufacturing of key-panels or key-boards. In this mode of construction, no vias are available on the P.C.B. so connections to central contact pads must be brought out on the same side of the substrate as the switching device is mounted upon. This can be permitted by a bridging structure, 53, in conjunction with a multi-legged contact-element. This permits standard-sized printed tracks on a P.C.B. to run below the device, without contacting any part of its rim. The bridging sections 53 on the switch element shown in Figure 21, are featured on all four sides of the device shown. The device is shown in a rounded-square plan-form, to provide an indexing feature so that devices may be correctly orientated for placement by automated systems.

The printed circuit pattern shown by items 55 and 56 in Figure 22 are configured in a "row-and-column" matrix, as commonly employed in interfaces between microcomputers and key-panels. The switch element is mounted so that the track 56 passes through the bridge section 53.

Figures 23 to 30, inclusive, show various plan-forms that are suitable for production as the proposed device. Various combinations of shapes and styles of contact-elements, including continuous rimmed styles and multi-footed styles are shown.

All shapes and styles shown have in common, the essential features of the proposed device. These shapes may be used where a designer, for instance desires a particular layout on a facia. The triangular switch elements shown in Figures 29 and 30 may be used as arrowheads.

Figures 31, 32 and 33 show several other means of dome-switch construction according to the present invention.

Figure 31 shows an externally flanged retaining device. This retraining device does serve to retain a domed element and can be made quite workable. It does not, however, provide a high-quality thrust-bearing surface or knife-edge bearing of the earlier embodiments.

Figure 32 shows an alternative embodiment of the device of the present invention. This device is formed from one piece of sheet material, with a rim folded under the domed section to provide a mounting base. The domed section takes a convoluted form to permit a small degree of flexibility. In operation, such a device would transfer lateral stresses into the bond and the device itself, so, although workable, it would have a short life compared to the earlier embodiments. It may be useful for single or low use devices.

Figure 33 shows the proposed device with through-hole pins added. This device has all the features of the proposed device, except that it is not a surface-mounting device, being essentially a device suitable only for hand-mounting and soldering. This embodiment may be useful for manual prototype manufacture or the like.

Some possible methods of fabricating the proposed device are shown in Figures 34 to 36.

Figure 34 depicts one basic method of manufacture, greatly simplified, of the proposed device. The component diagrams are shown scaled to approximately four times actual typical size.

Item 57 shows an annular ring die-cut from sheet-metal. Item 58 is a plan-view of the die-cut ring partially formed along the fold-line shown by item 57. Item 59 is an elevated view of the partially formed blank. Item 60 is an elevated, single-plane, profile view of the partly formed blank with a domed contact-element sitting upon it. Item 61 shows the device, completed by beading the bearer-element with a press-tool, to encapsulate the contact-element.

Figure 35 depicts the stages of bearer-element manufacture at approximately actual component size.

Such a method of manufacture will produce a high-quality result, although with some wastage of materials, such as the disc that is punched out of the centre of the bearer-element. This waste could be offset by punching progressively larger blanks from a prepared, surfaced sheet of metal. All waste metal could be re-cycled, meaning that the main wastage of this production system would be lost energy. One advantage of this production method is that the bearer-element will feature a continuous perimeter, without gaps or seams. It would be relatively to tool up to

press and form the bearer elements. The contact-elements, presumably domed devices, would be produced by existing volume-production methods.

Figure 36 shows some stages of another method of manufacture of the proposed device. This method, while more complex in its tooling requirements, also will produce relatively little waste, where waste may be a significant cost in the manufacture of devices such as these.

Item 62 shows a strip cut from a roll of prepared sheet-metal. The length of this strip equals the circumference of the bearer-element it is to produce. The metal strip is then rolled as shown by item 63 and formed by hardened pinch-rollers into the basic form of a bearer-element, although at this stage, the ring features an opened gap which increases the overall diameter of the element, so that a contact-element, 64 can be positioned in the internal plane of the bearer-element. The assembly is then rolled into a closed position so that there is a negligible gap between the two ends of the bearer-element material. This gap could be closed by fusion-welding, but the device should function without such extra effort. When the completed device is mounted, whether by surface-mount soldering, or fusion welding to a substrate P.C.B., the gap will be of little consequence, as long as the material it is made from is strong enough to resist crushing in ordinarily expected circumstances of end-product use.

Item 67 shows that blanks for the bearer elements could be cut from a formed tube which may, if desired, be seamlessly fusion-welded or be left with an open slit which would be closed later in the process. If the tube is butt-welded, then another method of closure of the bearer-element, about the contact-element, would be required.

Throughout this specification various indications have been given as to the scope of this invention but the invention is not limited to any one of these but may reside in two or more of these combined together. The examples are given for

illustration only and not for limitation.

Throughout this specification and the claims that follow unless the context requires otherwise, the words 'comprise' and 'include' and variations such as 'comprising' and 'including' will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Dated this 6th day of November, 2003.

Philip Adrian Sjostrom
By his Patent Attorneys
<u>MADDERNS</u>

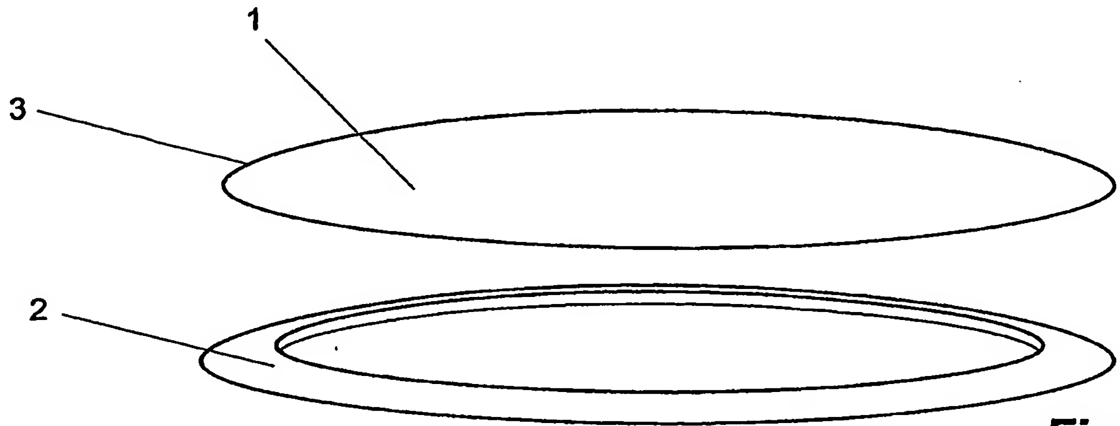
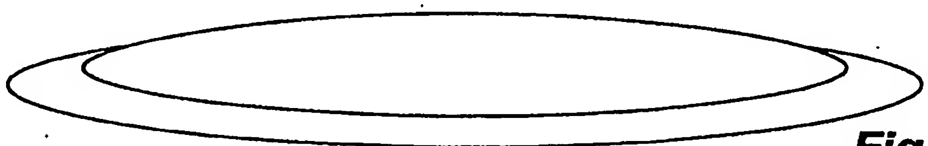


Figure 1



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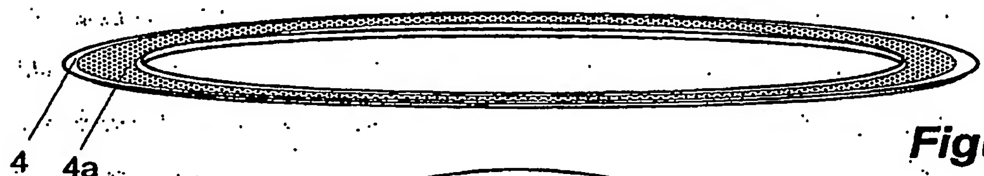

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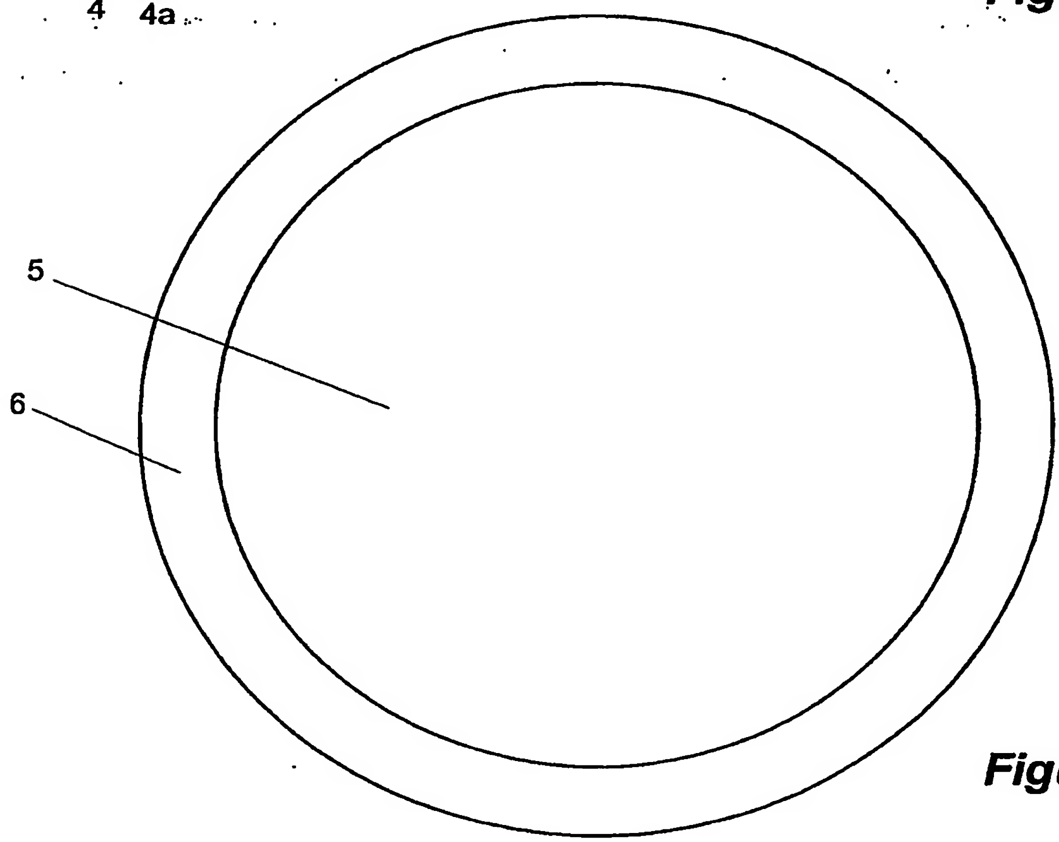

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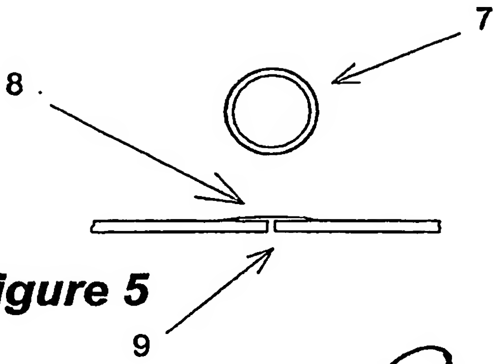

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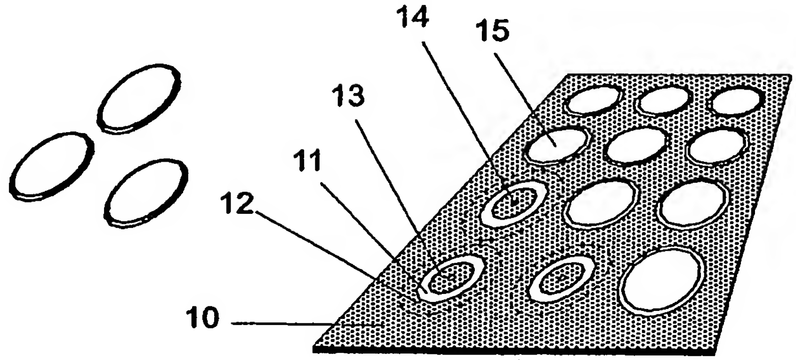

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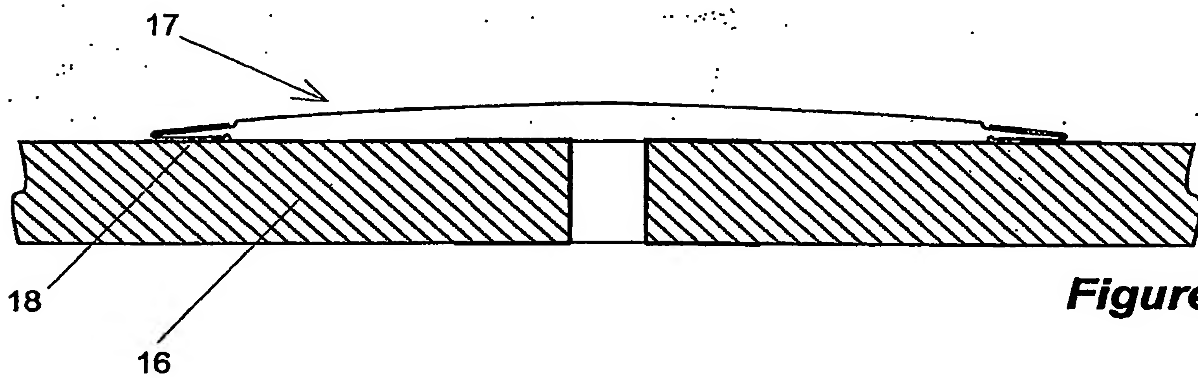

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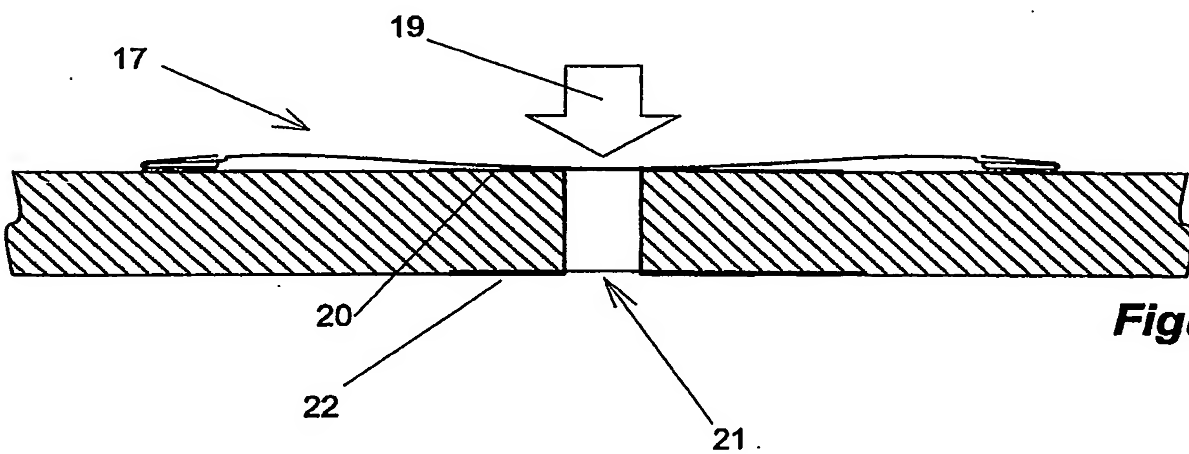

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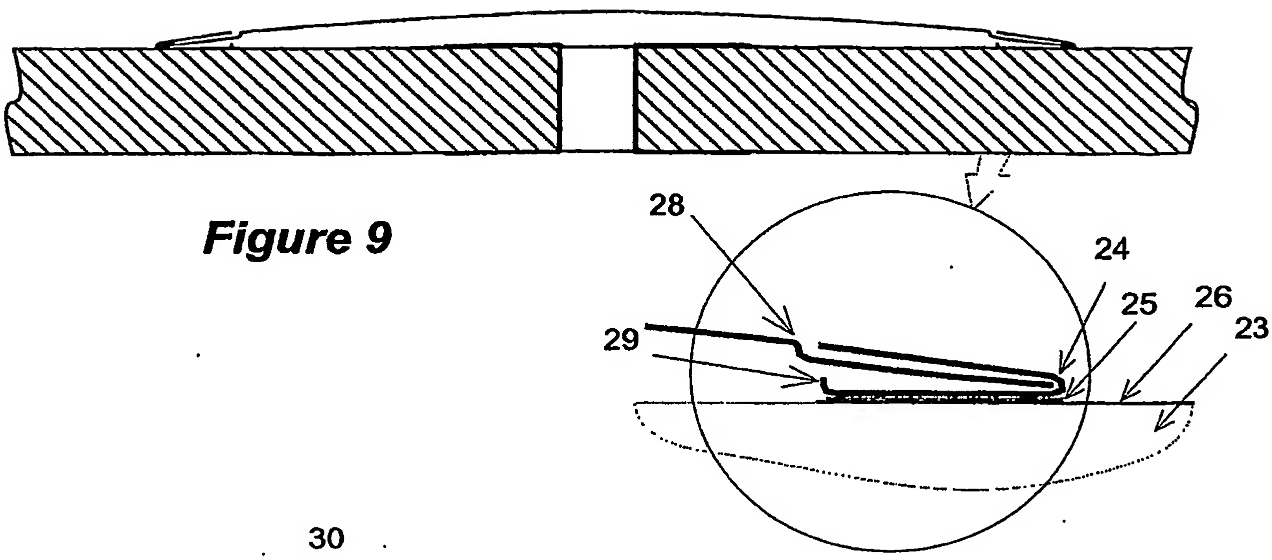

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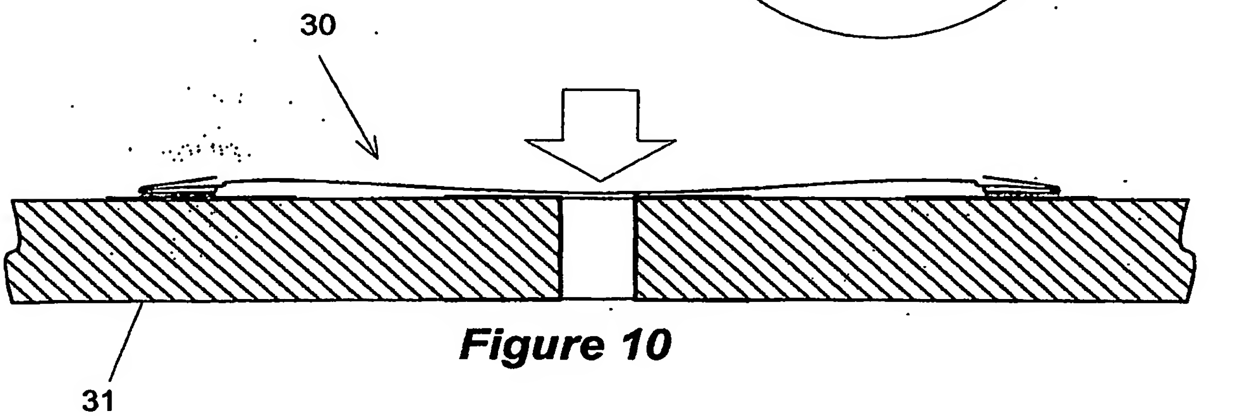

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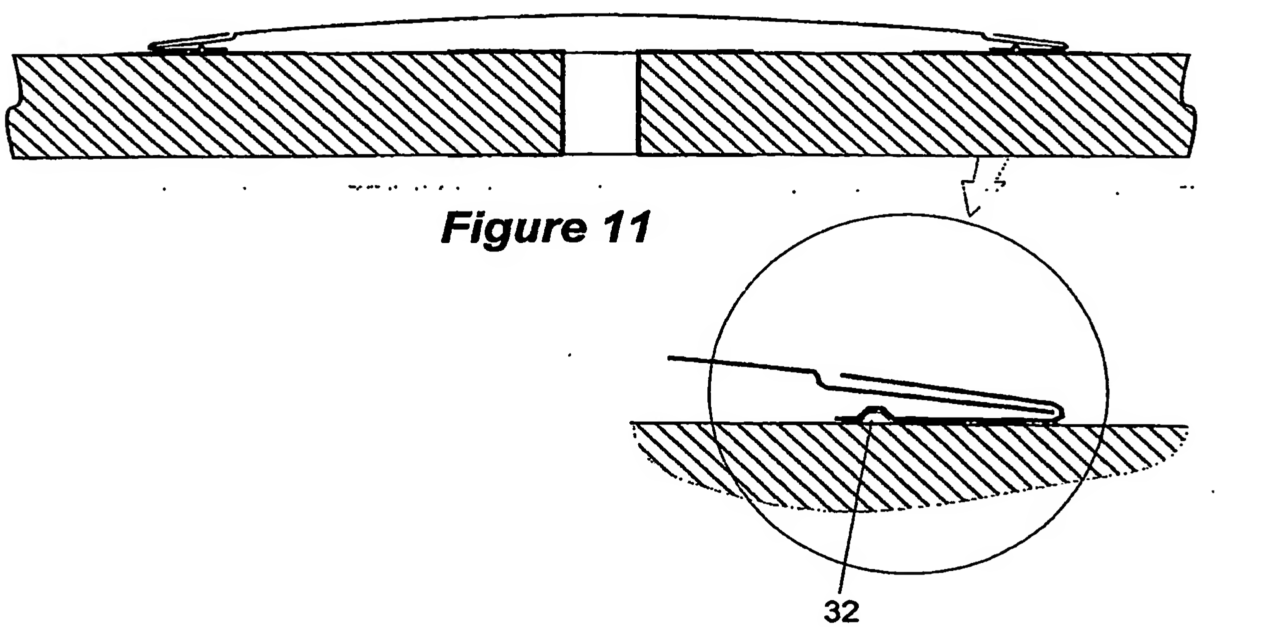

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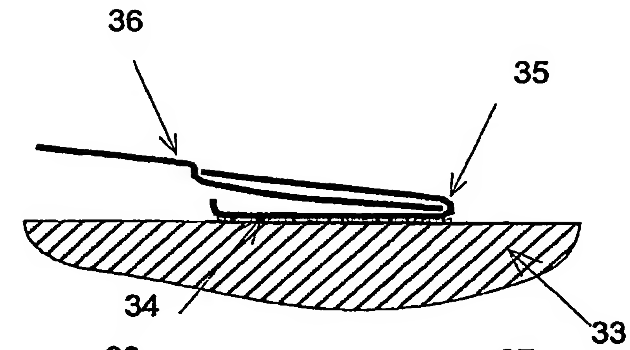

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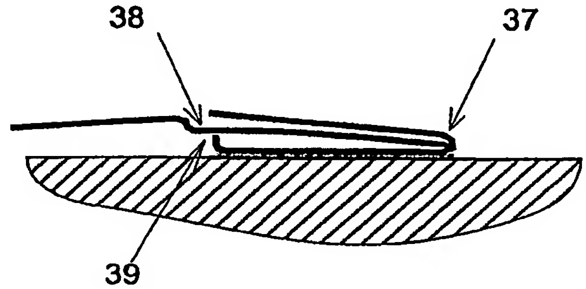

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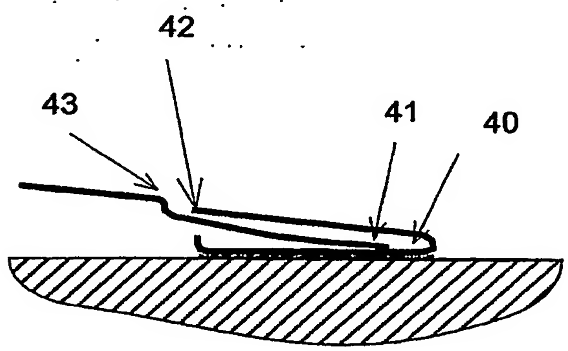

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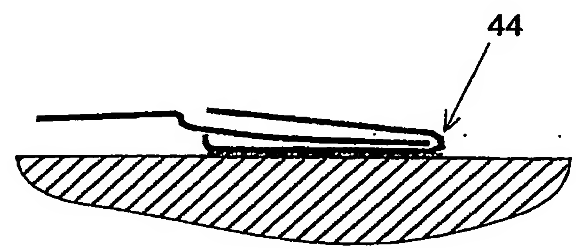

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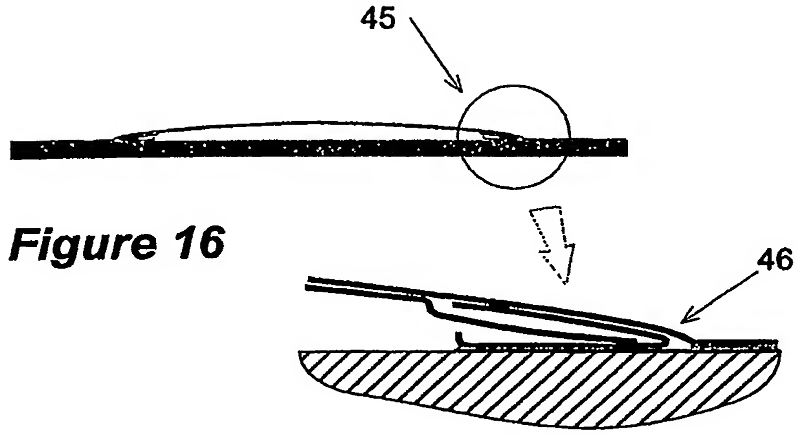

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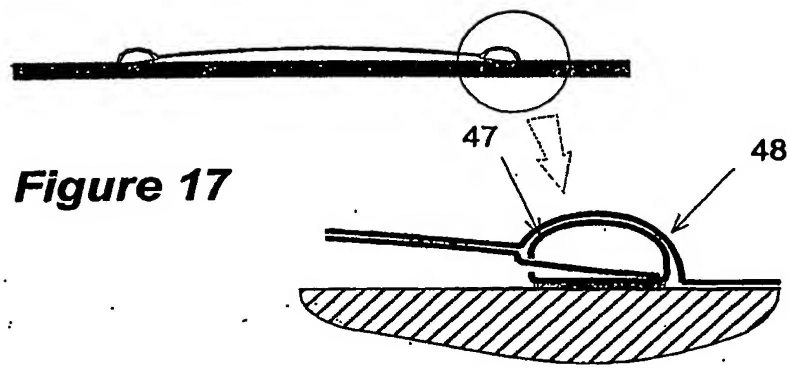

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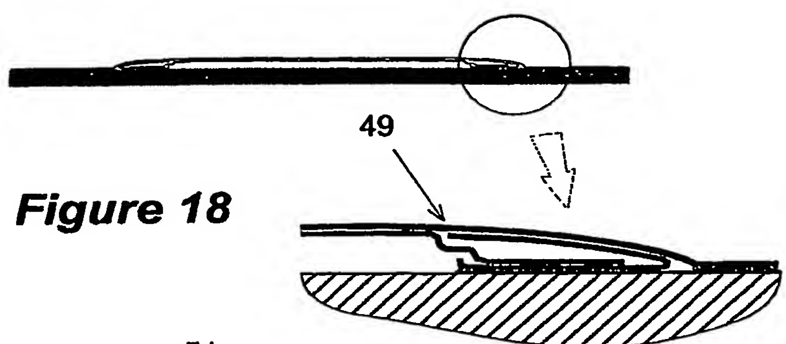

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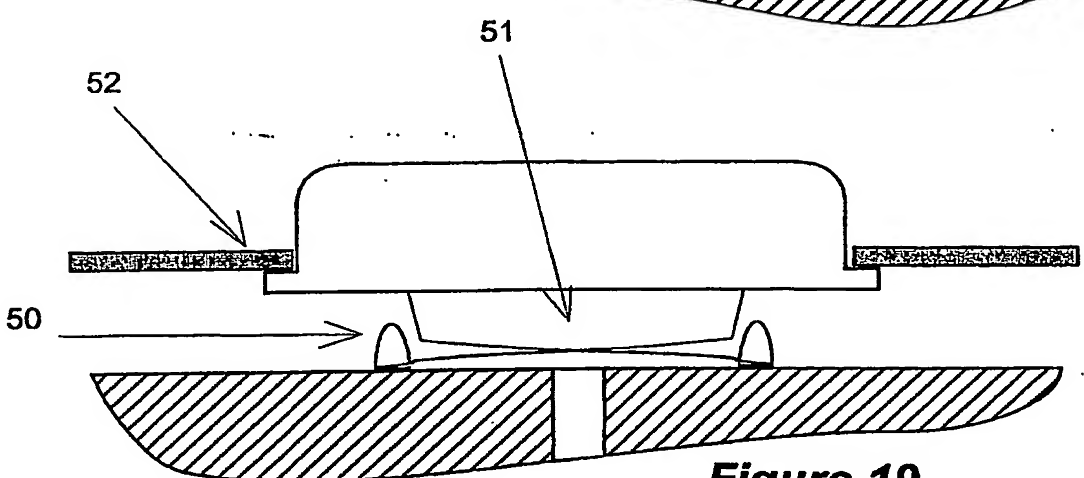

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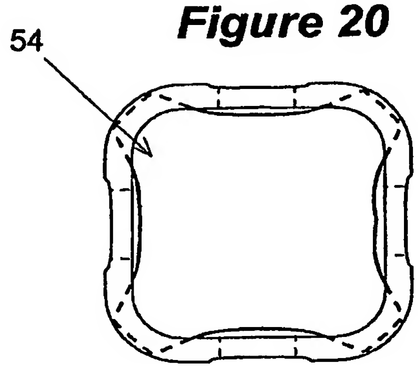

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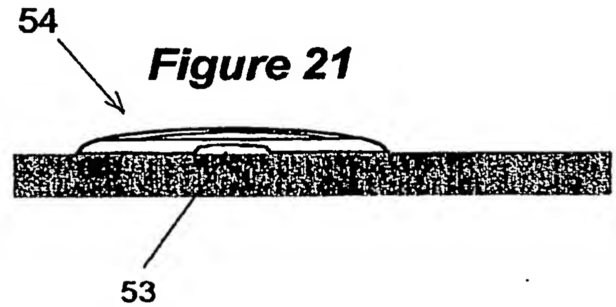

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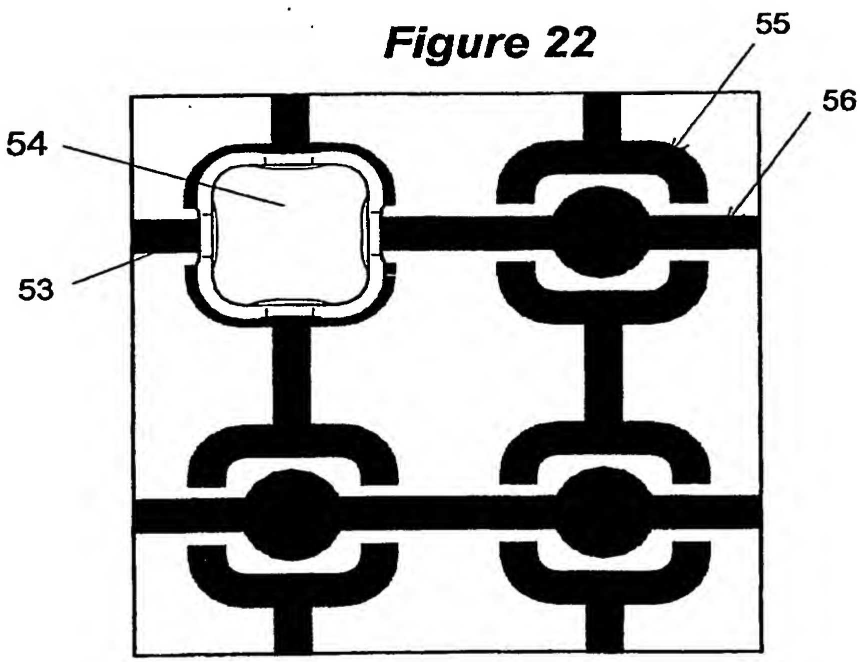

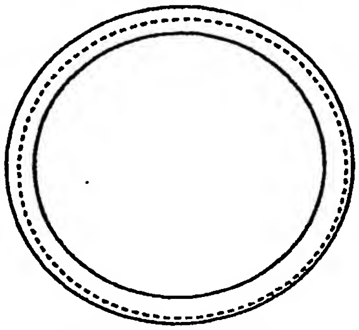

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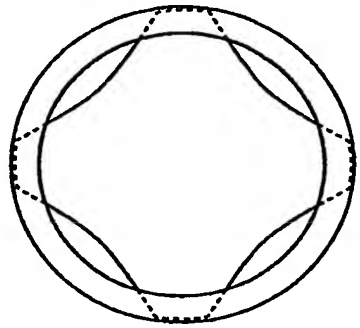

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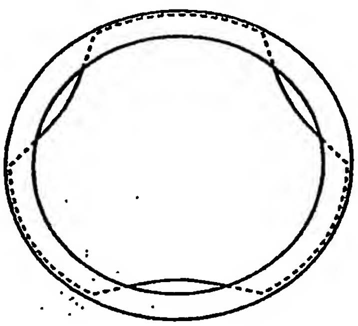

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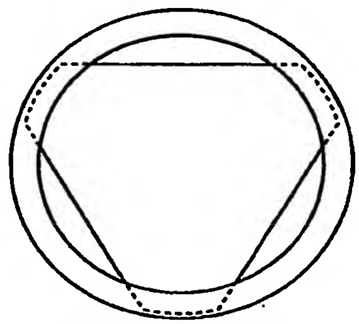

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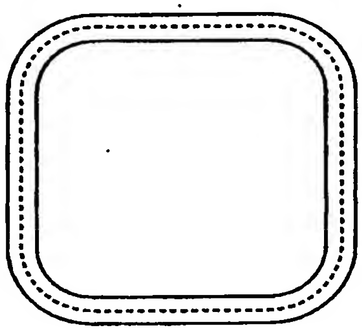

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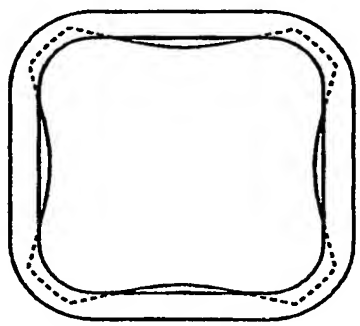

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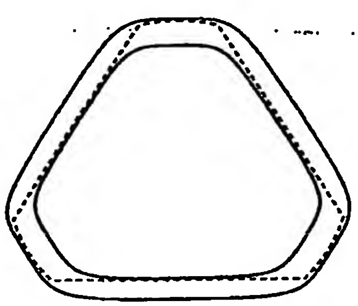

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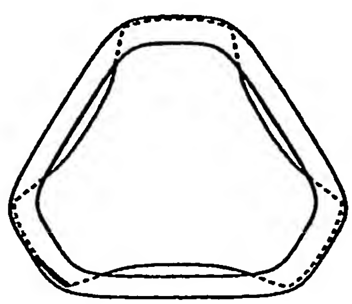

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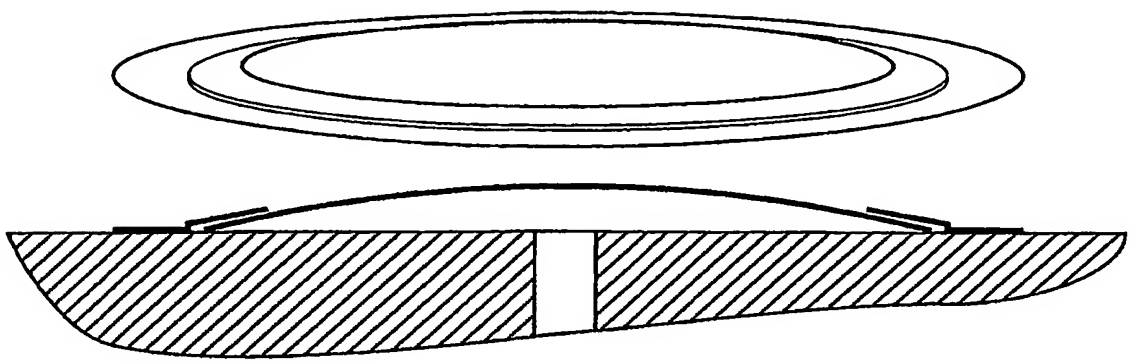

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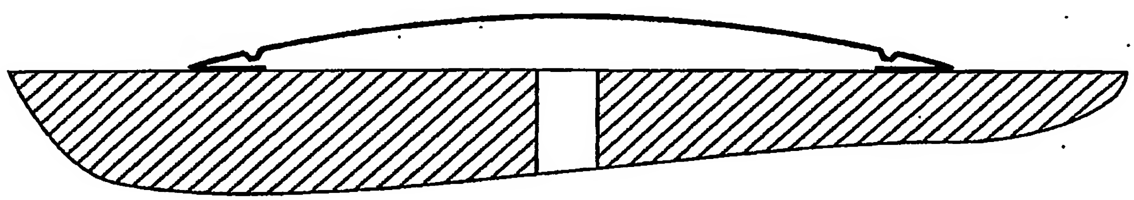
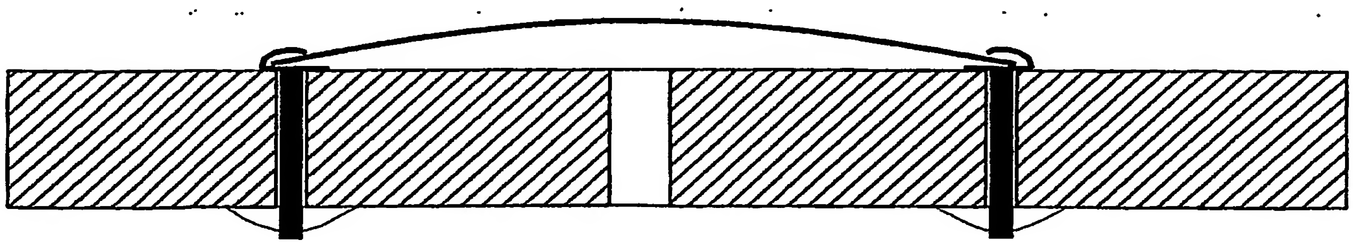
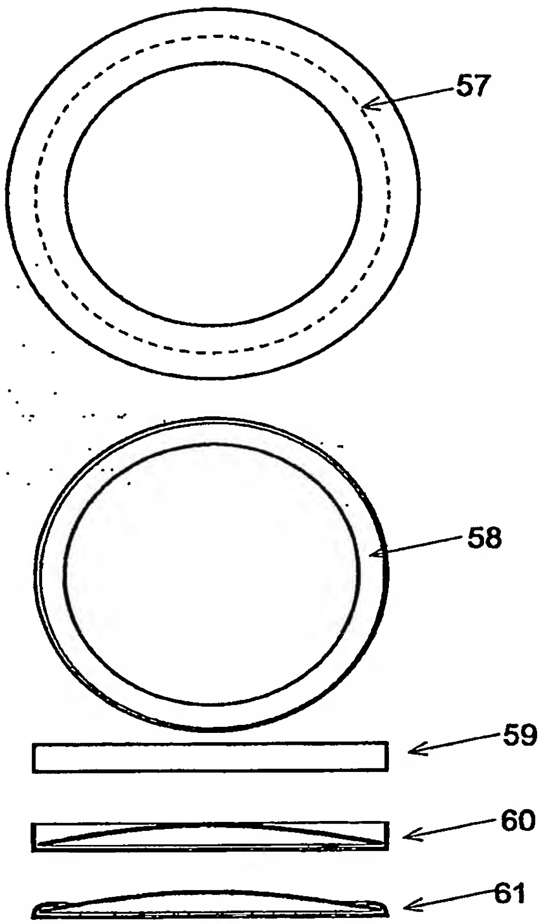


Figure 32

Figure 33





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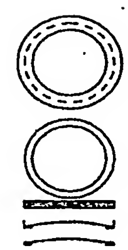

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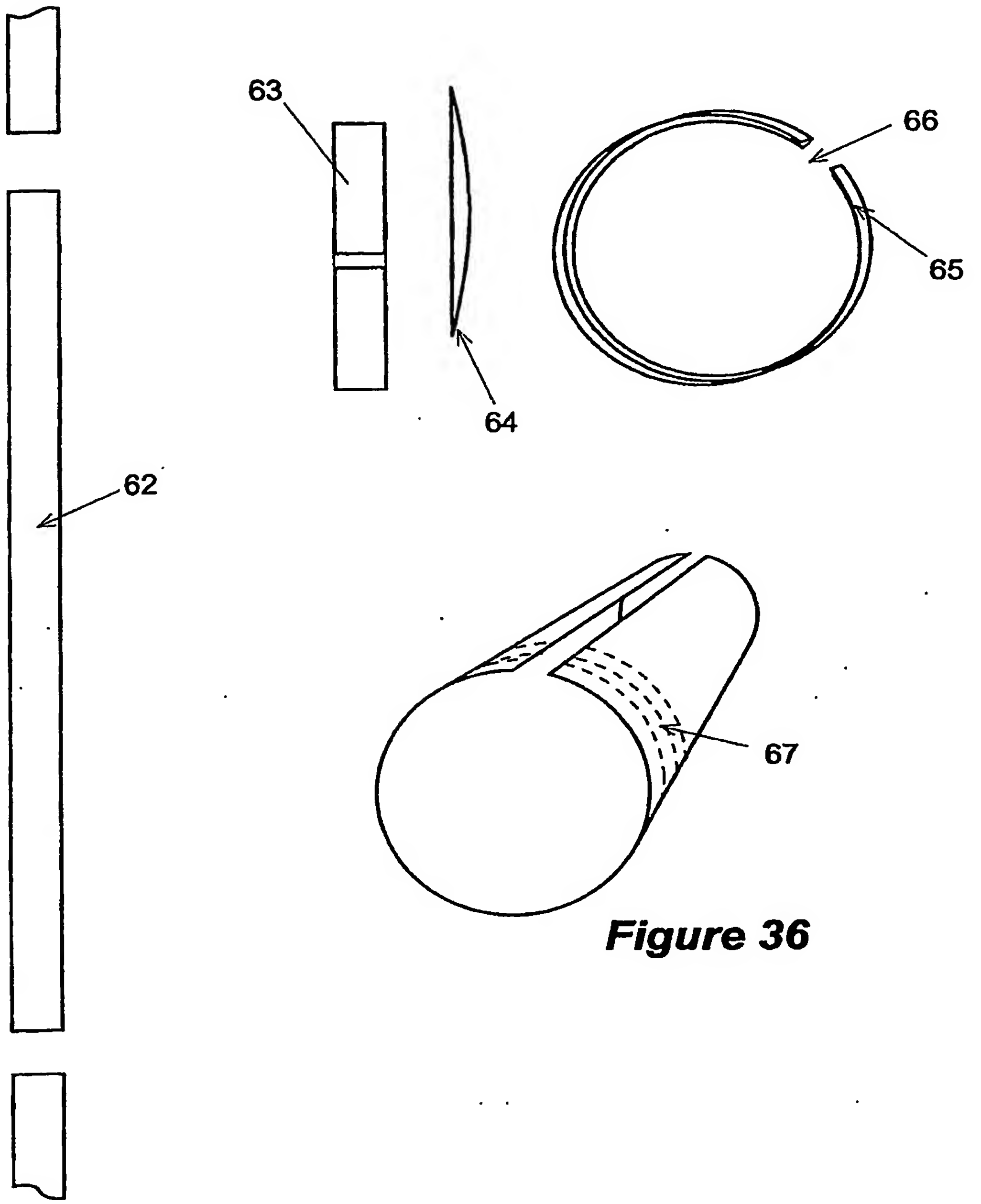

Figure 36

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